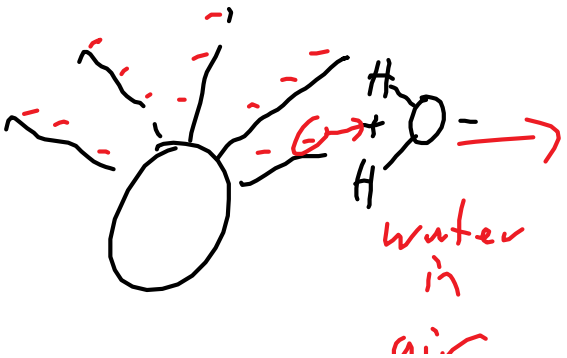
Electrostatics - Coulomb's Law

There is a quantity called charge, q or Q.
It is positive, negative or neutral.
Like charges repel, opposites attract
Neutral charges:
Why does a charged balloon stick to the neutral wall?
Charges on the wall move.



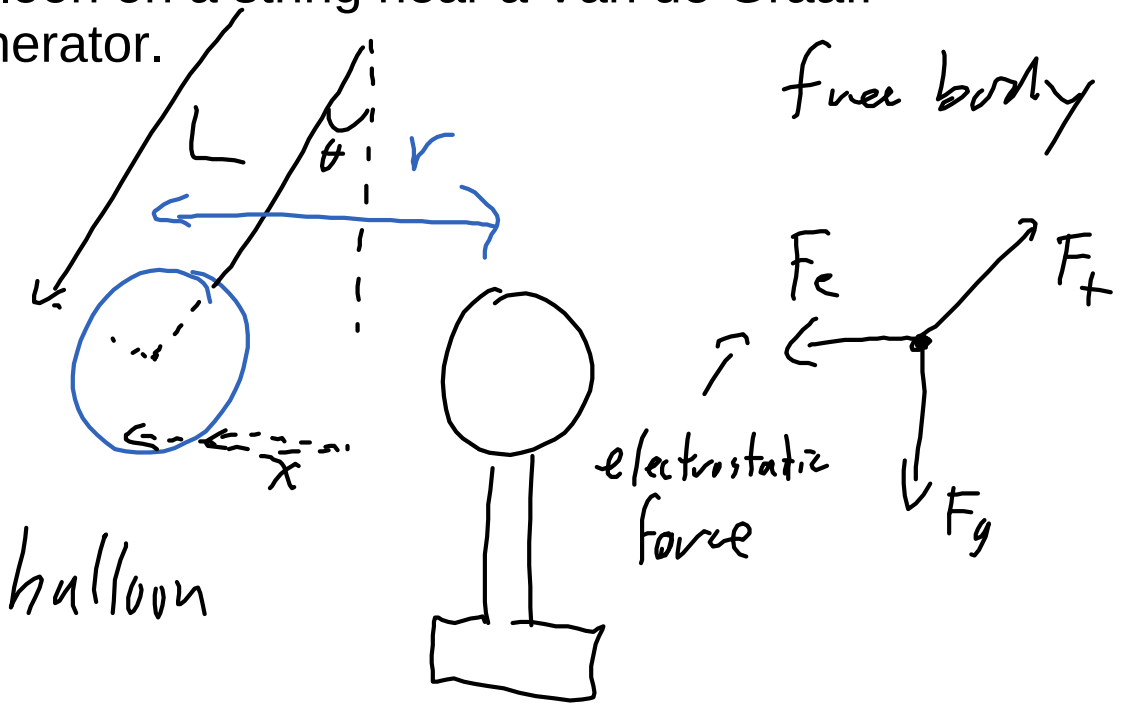
hair

in air

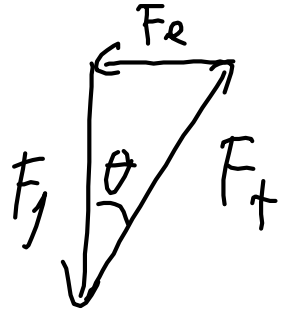
Some charge is lost over time from water molecules (they are polar)

Mini Informal Lab Demonstration

Balloon on a string near a Van de Graaff generator.



Vector Add

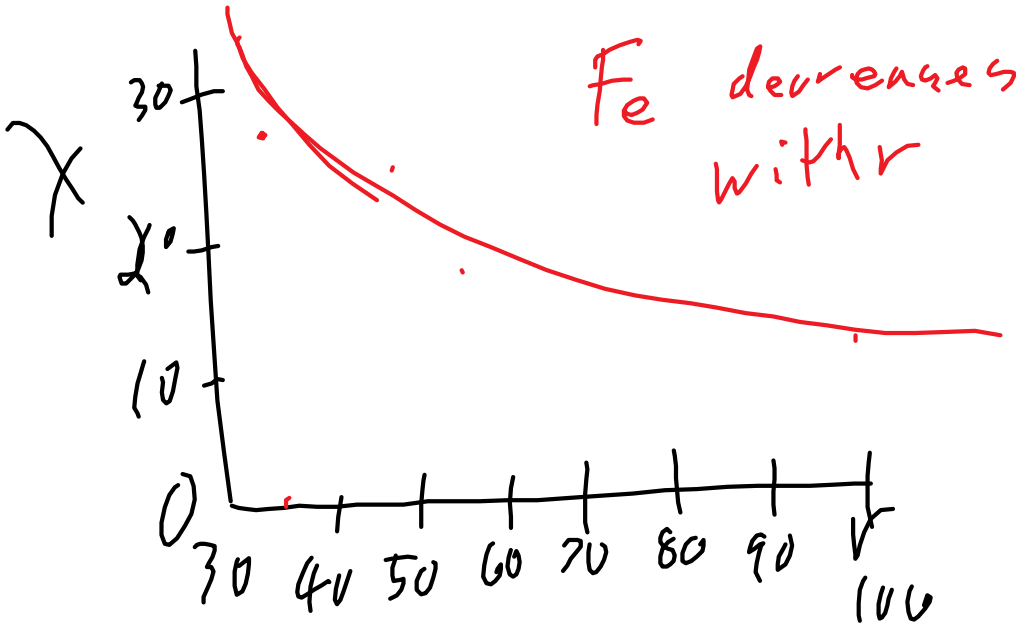


$$\tan\theta = \frac{F_e}{F_g} \quad \text{small angles} \quad \alpha \quad \sin\theta = \frac{x}{L}$$

$$F_e \propto x$$

graph X vs r will look like Fe vs r

X	15	24	26	29 (30)	10
r	58	50	35	40	100



Coulomb's Law

If the experiment was done more carefully, we could derive the relationships as an inverse square one.

$F_e \propto 1/r^2$

It is also proportional to the amount of charge on each object, q and Q.

$F_e = kqQ/r^2$

F_e is the electrostatic force of attraction or repulsion between the two charged objects, in Newtons, N.

Q and q are two charges, measured in Coulombs, C. One electron or proton has a charge of 1.602×10^{-19}C.
$e = 1.602 \times 10^{-19}$C

r is the distance between the centre of the charges, in metres, m.

k is Coulomb's constant 9.0×10^9 Nm^2/C^2

Eg.

1. A hydrogen atom has a radius of 5.0×10^{-11}m.
   a) What is the electrostatic force between the electron and proton?
   b) If the electron is in circular motion around the proton, what is the velocity of the electron?
   c) The mass of an electron is 9.11×10^{-31}kg, what is the acceleration of the electron?
2. A 20.0 g balloon on a string is 0.50m from a Van de Graaff generator with 5.0 μC. If the charge on the balloon is 1.0 μC, what is the angle of deflection of the string?

P436 Q 1-7 odds, p437 q 1-13 odds.

a) $F_e = \frac{kQq}{r^2}$

$$F_e = \frac{9\times10^{9}\ \frac{N m^2}{C^2}\left(1.602\times10^{-19}\ C\right)^2}{\left(5.0\times10^{-11}\ m\right)^2}$$

$$= \boxed{9.2\times10^{-8}\ N} \leftarrow \text{attractive if negative}$$

b) $F_e = F_c$

$$9.2\times10^{-8}\ N = \frac{m v^2}{r}$$

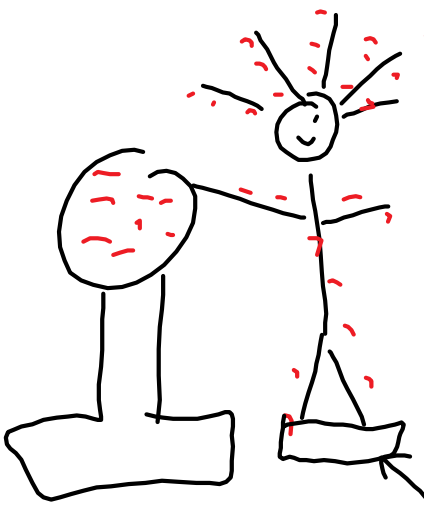
$$v = \sqrt{\frac{9.2\times10^{-8}\left(5.0\times10^{-11}\right)}{9.11\times10^{-31}\ kg}}$$

$$= \underline{2.3\times10^{6}\ m/s}$$

c)

Block 1-1
Electrostatics 2, Coulomb's Law

Demonstrations:
Van de Graaff generator and Agnes' hair.

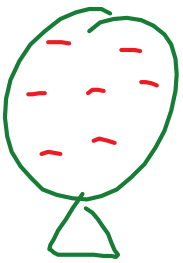


← hair gets charged and repels each other

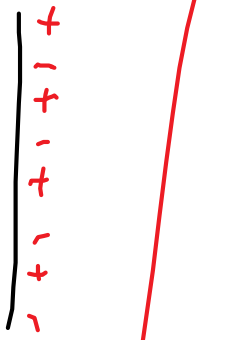
insulated – electrons don't conduct through

Van de Graaff lid

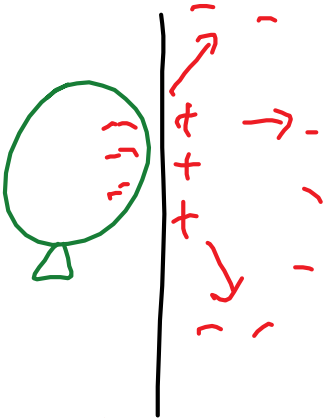
Balloon sticks to a Neutral wall What's the deal?



balloon



wall

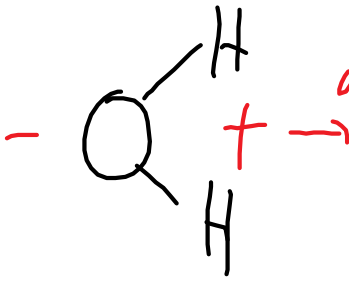


electrons move away, Positive charge attracts more

strongly because it is

Why does the balloon lose charge over time?

Water is a very polar molecule - positive and negative side.

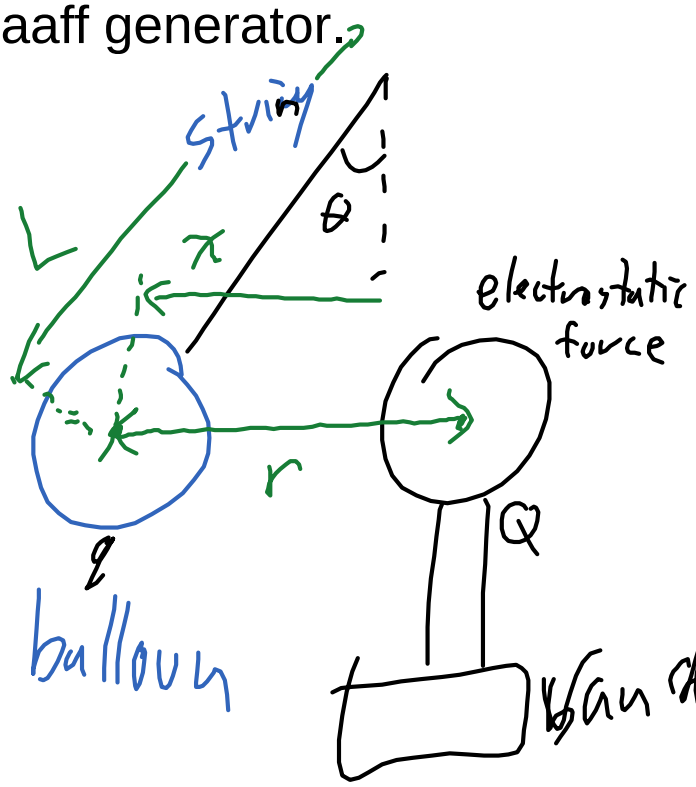


attracted to balloon captures electron

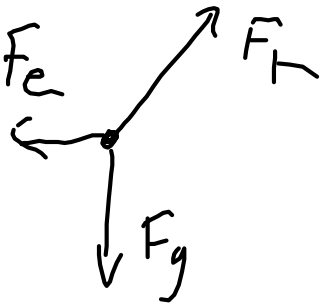
H_2O^-

repelled takes away charge

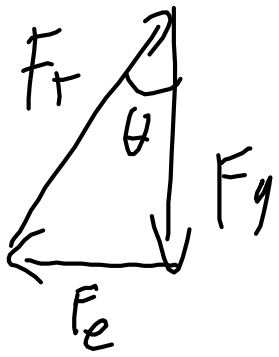
Mini Lab-
Charged balloon on a string near a Van de Graaff generator.



free body diagram



Vector Addition



$$\tan\theta = \frac{F_e}{F_g}$$

$$\sin\theta = \frac{x}{L}$$

for small θ

$\tan\theta \approx \sin\theta$

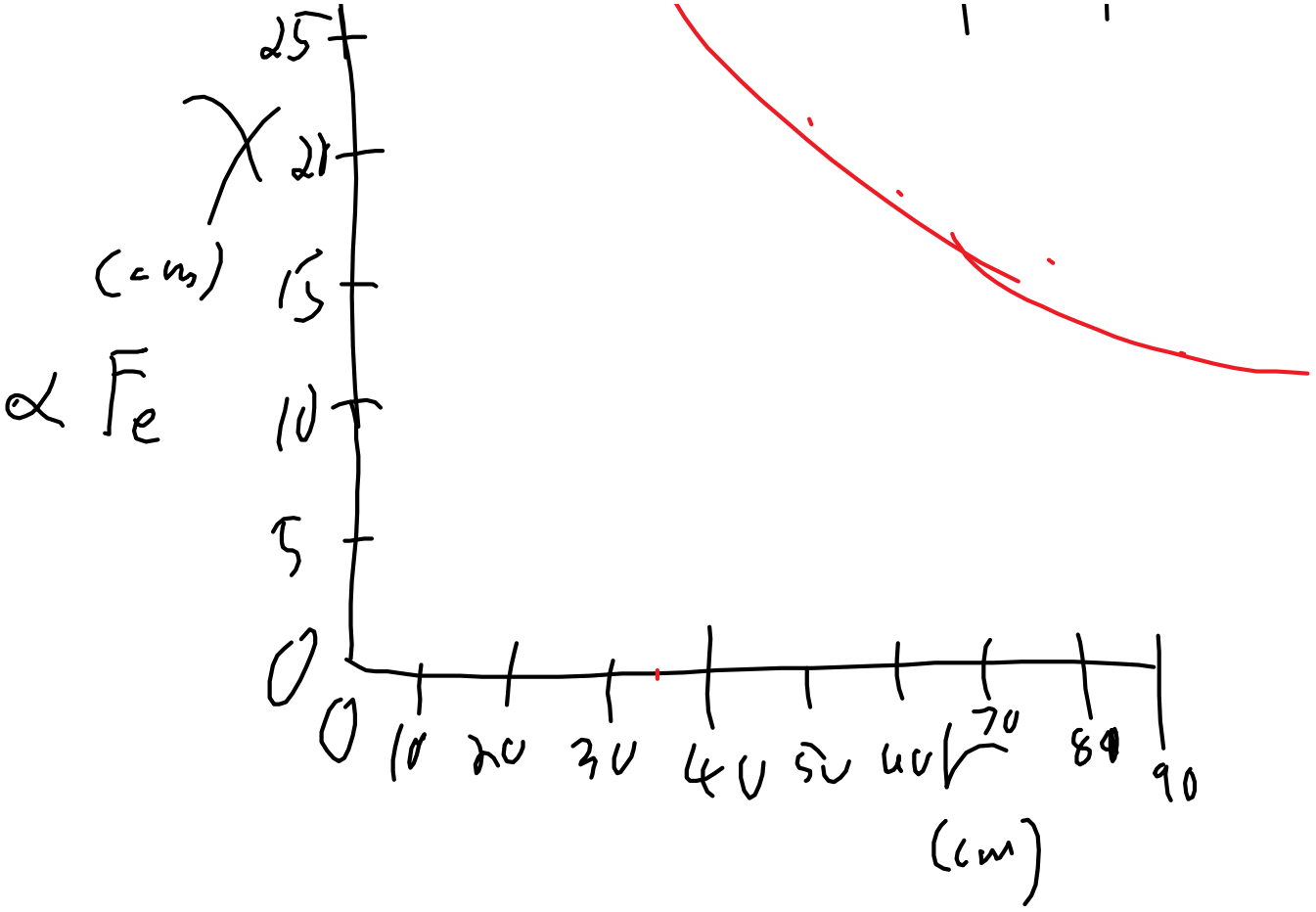
$$\frac{F_e}{F_g} = \frac{x}{L}$$

graph of x vs r will be the same shape as F_e vs r

x (cm)	7	11	16	20	26	32
r (cm)	90	76	64	55	42	35

30+

25+



If you did the experiment many times very carefully (no charge lost from the balloon) the graph should be an inverse square relationship.

$F_e \propto 1/r^2$
(proportional to)

Coulomb's Law:

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